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BIOLOGY
HIGHER LEVEL
PAPER 3

Candidate session number

Monday 12 May 2014 (morning)

1 hour 15 minutes

Examination code

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INSTRUCTIONS TO CANDIDATES

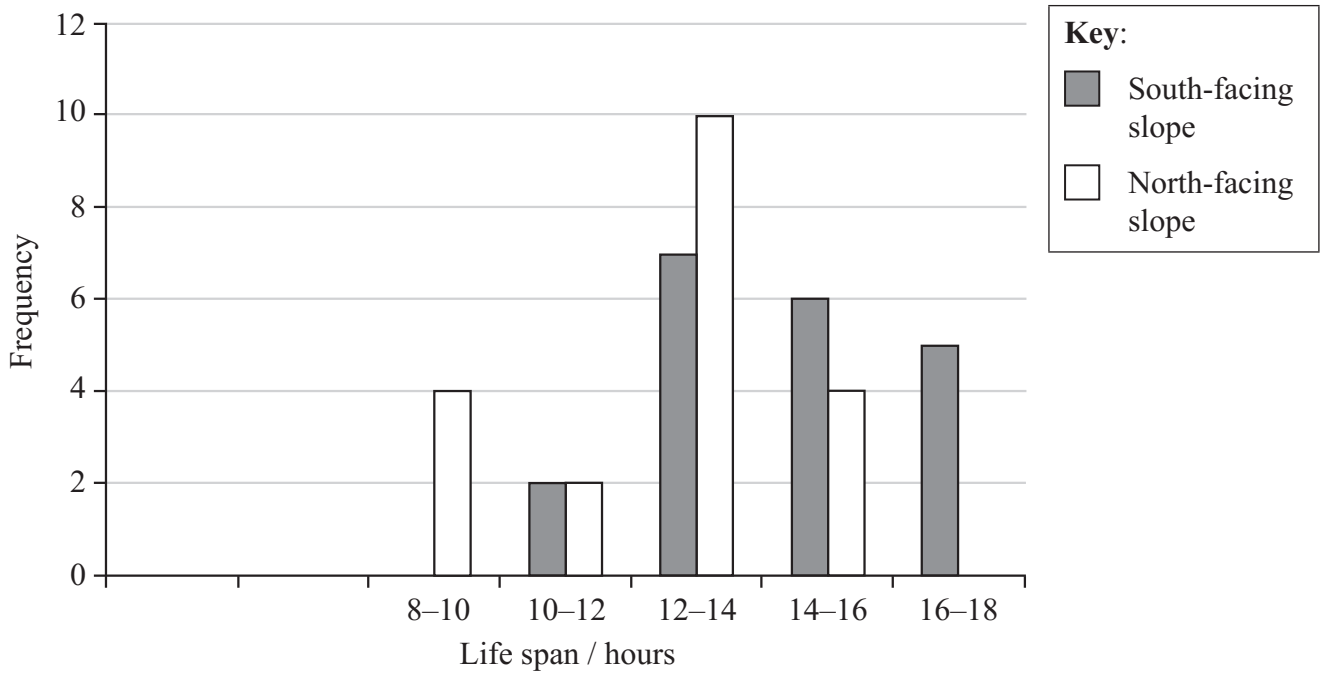
- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Answer all of the questions from two of the Options.
- Write your answers in the boxes provided.
- A calculator is required for this paper.
- The maximum mark for this examination paper is *[40 marks]*.

Option	Questions
Option D — Evolution	1 – 3
Option E — Neurobiology and behaviour	4 – 6
Option F — Microbes and biotechnology	7 – 9
Option G — Ecology and conservation	10 – 12
Option H — Further human physiology	13 – 15

Option D — Evolution

1. Evolution Canyon is a steep sided rocky valley near Mount Carmel in Israel. There are populations of fruit flies (*Drosophila melanogaster*) living on the north facing and south facing slopes of the canyon. Fruit flies are sensitive to drought conditions and die if they become desiccated.

Twenty samples of fruit flies were collected from both sides of the canyon. They were subjected to the same conditions of drought stress and the life span (in hours) of the adult flies was measured.



[Source: Korol *et al.* (2006) 'Drosophila flies in "Evolution Canyon" as a model for incipient sympatric speciation'. *PNAS*, 103 (48), pp. 18184–18189. Figure 1. Copyright 2006 National Academy of Sciences USA.]

(a) Compare the data for the North and South-facing slopes. *[3]*

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(Option D continues on the following page)

(Option D, question 1 continued)

(b) Genetic factors affect drought tolerance in *Drosophila melanogaster*. Deduce, with a reason, which of the slopes of the canyon has the drier climate. *[1]*

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(c) Discuss whether the populations on the two slopes could evolve into two species. *[3]*

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(Option D continues on the following page)

(Option D continued)

2. (a) (i) Define *half-life*. *[1]*

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(ii) Outline the methods used for dating fossils and rocks using ^{40}K. *[2]*

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(b) (i) In fruit flies (*Drosophila melanogaster*) the allele for long wings is dominant to the allele for short (vestigial) wings. In a laboratory population of 200 flies there were 168 with long wings. Using the Hardy-Weinberg equation, calculate the percentage of flies that would be heterozygous for this characteristic. Show your working. *[2]*

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(ii) State **two** assumptions made when using the Hardy-Weinberg equation to calculate allele frequencies. *[1]*

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(Option D continues on the following page)

(Option D, question 2 continued)

(c) Define *clade*. *[1]*

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(Option D continues on the following page)

(Option D continued)

3. Explain the endosymbiotic theory for the origin of eukaryotes and the evidence for it. *[6]*

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End of Option D

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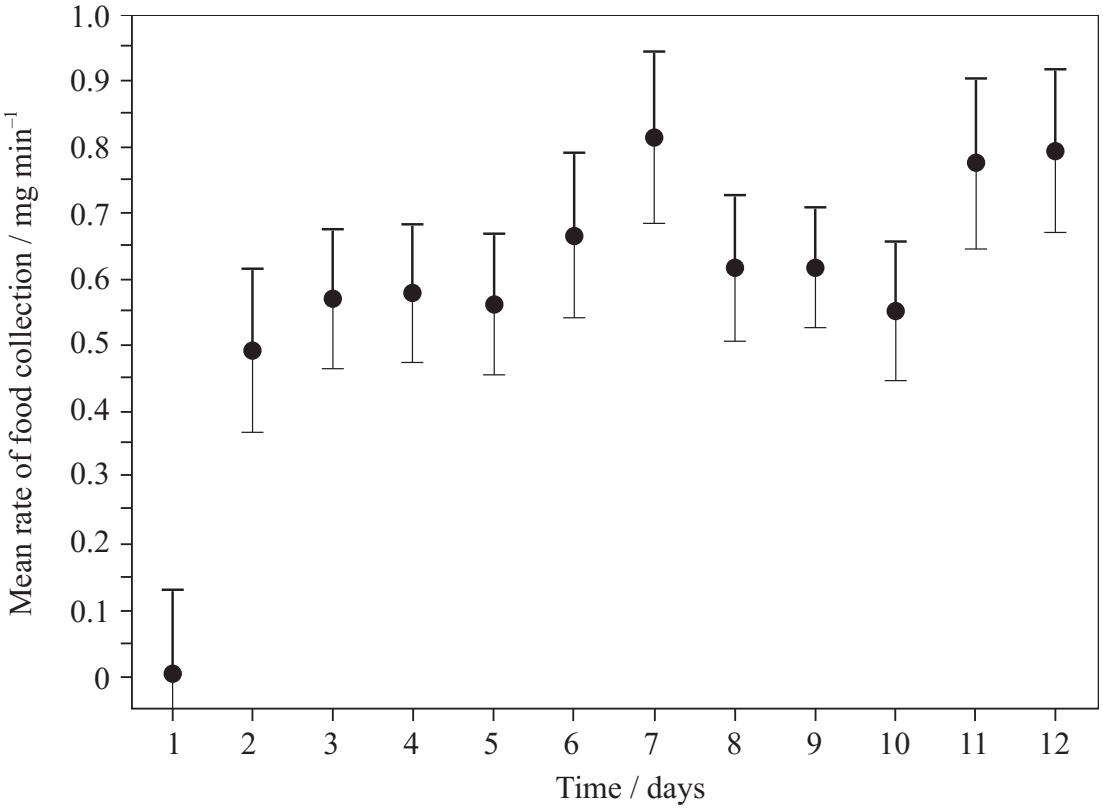
Answers written on this page
will not be marked.

Option E — Neurobiology and behaviour

4. Honeybees (*Apis mellifera*) collect nectar from flowers. This involves finding flowers that are producing nectar, moving efficiently from flower to flower and then returning to the colony by as straight a route as possible. It is the worker bees that forage for food and they do this for around two weeks after which many of them die.

In a study in Southern Ontaria, Canada, thirty eight individual worker bees that had not yet started foraging were marked and the mass of food collected on each foraging flight was measured upon their return to the colony. Measurements were carried out over a twelve day period.



[Source: Adapted from M. Schippers *et al.* (2006) 'Lifetime performance in foraging honeybees: behaviour and physiology', *Journal of Experimental Biology*, 209, pp. 3828–3836. Reproduced with permission of Company of Biologists Ltd via Copyright Clearance Center.]

(a) State the difference in mean rate of food collection on Day 7 compared with Day 6, giving the units. *[1]*

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(Option E continues on the following page)

(Option E, question 4 continued)

(b) Using the evidence provided by the data evaluate the hypothesis that the mean rate of food collection increases during the twelve days after the start of foraging on Day 1. *[3]*

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(c) Suggest reasons for the day to day rises and falls in the mean rate of food collection. *[2]*

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(Option E continues on the following page)

(Option E continued)

5. (a) Explain how sound is perceived by the ear. *[3]*

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(b) (i) State **two** differences in the way rod and cone cells function. *[2]*

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(ii) Explain the pupil reflex in bright light. *[3]*

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(Option E continues on the following page)

(Option E continued)

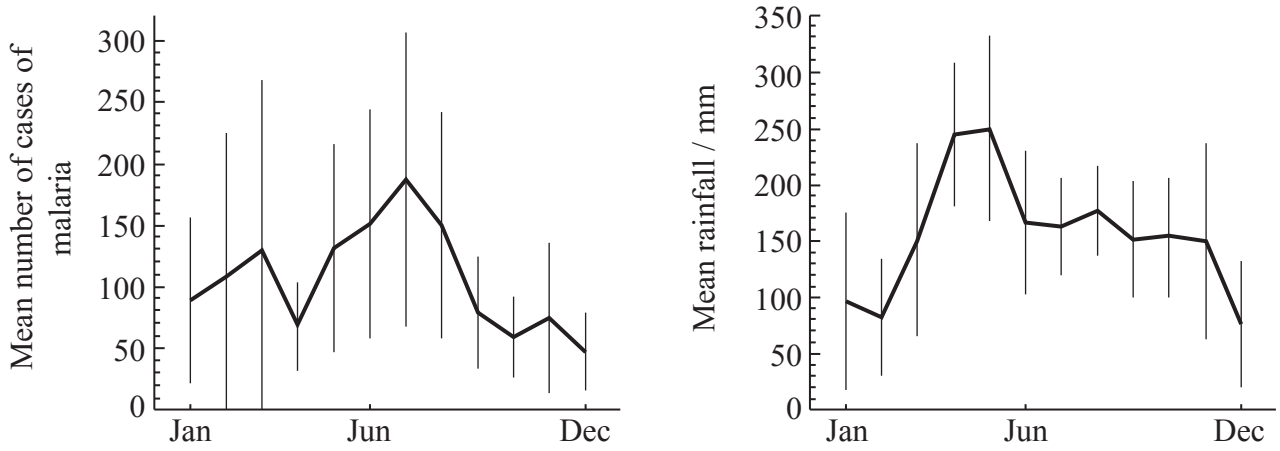
6. Outline the development of bird song. *[6]*

End of Option E

Option F — Microbes and biotechnology

7. Malaria is a widespread disease in tropical Africa. A study looked at the outbreaks of malaria and annual rainfall patterns over a period of 30 years in an area of Western Kenya where many families live and work on tea estates in the highlands.

The graphs show the seasonal patterns of malaria and rainfall at a tea estate in Western Kenya. In both graphs the vertical bars correspond to one standard deviation above and below the mean.



[Source: Adapted from M. Pascual *et al.* (2008) 'Shifting patterns: malaria dynamics and rainfall variability in an African highland', *Proceedings of the Royal Society B: Biological Sciences*, 275 (1631), pp. 123–132, by permission of the Royal Society.]

(a) State the mean number of cases of malaria and the mean monthly rainfall in June. *[1]*

Cases of malaria: . . . . . .

Monthly rainfall: . . . . . mm

(b) Compare the patterns shown by the malaria and rainfall graphs. *[2]*

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(Option F continues on the following page)

(Option F, question 7 continued)

(c) Evaluate the hypothesis that the pattern of malaria outbreaks is caused by variations in annual rainfall. *[2]*

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(d) Suggest **two** possible reasons apart from the variation in rainfall for the seasonal pattern of malaria outbreaks. *[2]*

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(Option F continues on the following page)

(Option F continued)

8. (a) (i) Outline the symptoms, mode of transmission and treatment of **one** named example of food poisoning. *[3]*

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(ii) Outline the use of acids and high sugar concentrations in food preservation. *[2]*

Acids: . . . . . .
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Sugar: . . . . . .
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(b) Distinguish between intracellular and extracellular bacterial infection using *Chlamydia* and *Streptococcus* as examples. *[2]*

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(Option F continues on the following page)

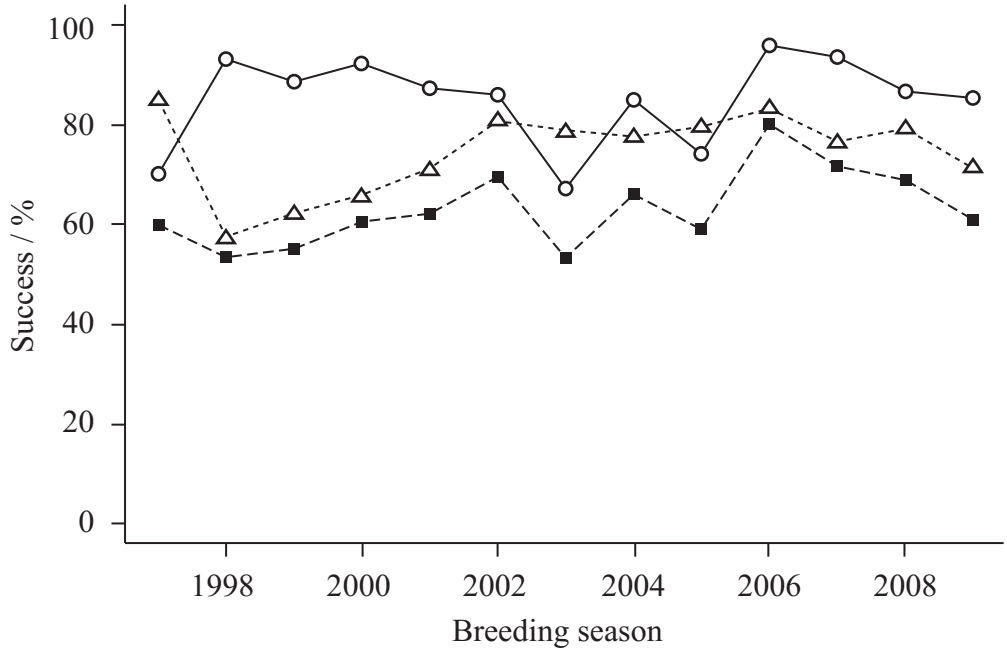
(Option F continued)

9. Discuss the prion hypothesis for the cause of spongiform encephalopathies. *[6]*

End of Option F

Option G — Ecology and conservation

10. The breeding success of white-flippered penguins (*Eudyptula minor albosignata*) was monitored in New Zealand, between 1997 and 2009. This involved counting the number of eggs laid and calculating the percentage that hatched (successfully emerged from egg) and the percentage of chicks that fledged (became independent of their parents). Successful breeding contributes to the survival of penguin colonies.



Key:

△ Hatching success $\left(\frac{\text{eggs hatched}}{\text{eggs laid}}\right)$

○ Fledging success $\left(\frac{\text{chicks fledged}}{\text{eggs hatched}}\right)$

■ Breeding success $\left(\frac{\text{chicks fledged}}{\text{eggs laid}}\right)$

[Source: W. J. Allen *et al.* (2011) 'Factors affecting breeding success of the Flea Bay white-flippered penguin (Eudyptula minor albosignata) colony', *New Zealand Journal of Ecology*, 35 (3), pp. 199–208. Reprinted with permission.]

(a) Identify the year that has the highest breeding success. *[1]*

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(Option G continues on the following page)

(Option G, question 10 continued)

(b) Describe the trend in hatching success between 1998 and 2006. *[1]*

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(c) Compare breeding and fledging success between 1997 and 2009. *[2]*

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(d) In the year 1998 there is relatively low breeding success. Using all the data, suggest a possible reason for this situation. *[1]*

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(e) In 2003 and 2005 low fledging and breeding success is combined with relatively high hatching success. Suggest **two** possible reasons for this. *[2]*

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(Option G continues on the following page)

(Option G continued)

11. (a) (i) List **two** factors that affect the distribution of animal species. *[2]*

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(ii) Outline the principle of competitive exclusion. *[2]*

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(b) Outline how a reliable estimate of the population of an animal species can be obtained using the capture-mark-release-recapture technique. *[3]*

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(Option G continues on the following page)

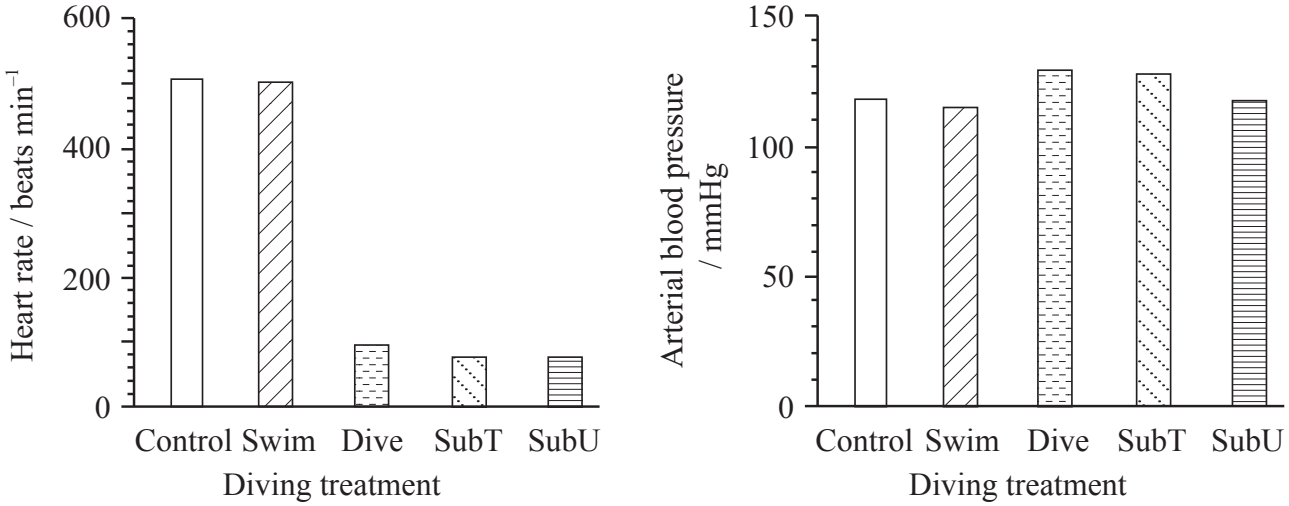
(Option G continued)

12. Discuss how alien species can impact on the environment, giving a specific example of each of the impacts discussed. *[6]*

End of Option G

Option H — Further human physiology

13. The diving response is a powerful autonomic reflex in mammals. Underwater submersion causes breath holding (apnoea), slowing of the heart rate (bradycardia) and vasoconstriction of peripheral blood vessels. Rats trained to dive underwater were used to investigate the changes in heart rate and mean arterial blood pressure during diving.



Key: Control – rats not in water
Swim – rats swimming on the surface
Dive – rats voluntarily diving
SubT – rats trained to dive involuntarily submerged
SubU – untrained rats involuntarily submerged

[Source: Adapted from W. Panneton *et al.* (2010) 'The rat: a laboratory model for studies of the diving response', *Journal of Applied Physiology*, 108 (4), pages 811–820. © The American Physiological Society (APS).]

(a) Calculate the change in heart rate that occurs when a rat dives voluntarily. *[1]*

. . . . . beats min^{-1}

(Option H continues on the following page)

(Option H, question 13 continued)

(b) Compare the effects of swimming and diving on heart rate with their effects on arterial blood pressure. *[2]*

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(c) Suggest reasons for the very large differences between the responses in swimming and diving rats. *[2]*

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Changes in heart rate and mean arterial blood pressure are greater in cold water than in warm water.

(d) Suggest reasons for the difference in heart rate and mean arterial blood pressure in cold water and in warm water. *[2]*

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(Option H continues on the following page)

(Option H continued)

14. (a) (i) State **one** example of a steroid hormone and **one** example of a protein hormone. *[2]*

Steroid hormone: . . . . . .

Protein hormone: . . . . . .

(ii) Outline the hormonal control of gastric juice secretion. *[2]*

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(b) Explain the mechanisms that cause ventilation rate to increase during exercise in humans. *[3]*

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(Option H continues on the following page)

(Option H continued)

15. Describe the process of erythrocyte and hemoglobin breakdown in the liver. *[6]*

End of Option H

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